Literature Cited

Dehgan, B. 1976. Experimental and evolutionary studies of relationships in the genus *Jatropha* L. (Euphorbiaceae). Ph.D. Dissertation, Department of Botany, University of California, Davis, California. 436 pp.

McVaugh, R. 1944. The genus *Cnidoscolus:* generic limits and intrageneric groups. Bull. Torrey Bot. Club. 71:457–474.

———. 1945a. The Jatrophas of Cervantes and of the Sessé and Mociño Herbarium. Bull. Torrey Bot. Club 72:31–41.

———. 1945b. The genus *Jatropha* in America: principal intrageneric groups. Bull. Torrey Bot. Club 72:271–294.

Mueller Argoviensis, J. 1866. *Jatropha. In* De Candolle (ed.), Prodromus Systematis Naturalis Regni Vegetabilis 15(2):1076–1105.

Pax, F. 1910. Euphorbiaceae-Jatropheae. *In* A. Engler (ed.), Das Pflanzenreich IV.147(Heft 42):1–148. Verlag Wilhelm Englemann, Leipzig.

Shreve, F. and I. L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford, California. Vol. I: x + 840 pp.

Standley, P. C. 1923. *Jatropha. In* Trees and shrubs of Mexico. Contr. U.S. Nat. Herb. 23:634–642.

Wilbur, R. L. 1954. A synopsis of *Jatropha,* subsection *Eucurcas,* with the description of two new species from Mexico. J. Elisha Mitchell Sci. Soc. 70:92–101.

# CHEMOTAXONOMIC STUDIES IN THE SAXIFRAGACEAE S.L. 9. FLAVONOIDS OF JEPSONIA

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*Jepsonia* is a small genus of the Saxifragaceae restricted to California and northern Baja California. Ornduff (1961) described the distylous nature of the flowers and, more recently, presented a detailed account of the ecology, morphology and systematics of the genus (Ornduff, 1969). No chemical study of the genus appears to have been done. An investigation of the polyphenolic constituents of *Jepsonia* was thus undertaken as part of a general chemotaxonomic survey of the family. It was hoped that flavonoid data might yield additional characters useful for characterizing the species and offer insights into the enigmatic relationships between *Jepsonia* and other genera in the family.

## Material and Methods

The plant collections used in this study are: *J. heterandra* Eastw., Bagby, Mariposa Co., Cal., 20 Mar 1970, G. D. Cromwell 101, RSA; *J. malvifolia* (Greene) Small, Santa Catalina Island, Los Angeles Co., Cal., 8 Mar 1970, R. F. Thorne 39392, RSA; *J. parryi* (Torr.) Small,

Old Mission Dam, San Diego Co., Cal., 12 Apr 1970, Cromwell 107, RSA; Old Mission Dam, San Diego Co., Cal., 2 Nov 1970, Cromwell 109, RSA; Los Alamos Canyon, Riverside Co., Cal., 15 Feb 1972, Cromwell 709, RSA; Jatay, Baja Cal., 21 Mar 1970, Thorne 39421 RSA; Baja Cal., Spring 1973, Tom Mulroy (Pomona College) (s.n.) RSA.

Flavonoid constitutents were isolated and purified by the procedures described by Wilkins and Bohm (1976a). The compounds were identified by chromatography against standards, partial and total hydrolyses, and ultraviolet spectral methods (Mabry et al., 1970). These procedures were used on the pooled extracts of *J. parryi* and the extract from *J. heterandra*. Compounds present in *J. malvifolia* were determined solely on the basis of chromatography against standards because of the small amount of plant material which was available.

## Results

The flavonoids of *Jepsonia* are based upon the common flavonols kaempferol, quercetin, and myricetin (Table 1). All compounds are 3–0–glycosylated derivatives. The compounds indicated as "K–acyl" and "Q–acyl" are gallic acid esters of the corresponding kaempferol–3–0–glucoside and quercetin–3–0–glucoside. The quantities available were too small to allow detailed study but the derivatives have chromatographic characteristics and color test behavior identical to those of the flavonol–3–0–glucoside–6″–gallyl derivatives identified in *Tellima* (Collins et al., 1975) and *Heuchera* (Wilkins and Bohm, 1976a, and unpubl.). Gallotannins were shown to be present by chromatography and characteristic color reaction using ferricyanide reagent but very limited material precluded further study.

One population of *Jepsonia parryi* was sampled in the autumn and in the spring and both collections were chemically identical. The flavonoid profiles of these samples were identical although there were differences in the relative concentrations of the compounds. No significance can be attributed to this quantitative variation without extensive additional sampling of this species.

## Discussion

Taxonomic opinion has been divided on the number of species of *Jepsonia*. The genus was considered to be monotypic by Jepson (1925, 1936) and Munz (1959) although its "polymorphous" nature was recognized by Munz (1959). At the other extreme Small and Rydberg (1905), Bacigalupi (1944) and Ornduff (1969) recognized three species. Ornduff (1969) based his taxonomic conclusions primarily on an array of morphological traits that separate the three species and on hybridizations among the species. He pointed out the importance of studying living material in the identification of species of *Jepsonia*.

We undertook study of the flavonoids of *Jepsonia* with the hope that

Table 1. Flavonoids and a Gallic Acid Derivative of Jepsonia.

| | *J. parryi* | *J. malvifolia*[a] | *J. heterandra* |
|---|---|---|---|
| Kaemferol–3–0–rhamnoside | + | + | – |
| Kaempferol–3–0–glucoside | + | + | + |
| Kaempferol–3–0–galactoside | trace | ND[b] | – |
| Quercetin–3–0–glucoside | + | + | + |
| Myricetin–3–0–glucoside | + | + | + |
| Kaempferol–3–0–rutinoside | + | + | + |
| Kaempferol–3–0–xylosylxyloside | + | + | + |
| Quercetin–3–0–rutinoside | + | + | + |
| Quercetin–3–0–xlyosylxyloside | + | + | + |
| Kaempferol–acyl[c] | + | + | – |
| Quercetin–acyl[c] | + | + | – |
| Gallotannin test[d] | + | + | + |

[a] determined by comparative chromatography only.
[b] ND = not determined.
[c] kaempferol– and quercetin–3–0–glucoside–?"–gallate.
[d] blue coloration with ferricyanide reagent.

additional characters of systematic value would be found that might shed light on the relationships among the species and of the genus (cf. Wilkins and Bohm, 1976a; Bohm and Wilkins, 1976). This study showed that there are very few differences among the species of *Jepsonia* in their flavonoid biochemistry. *Jepsonia parryi* and *J. malvifolia,* both occurring in southern California and Baja California, have an identical array of flavonoids. *Jepsonia heterandra* from the foothills of the central Sierra Nevada differs from these two species in that it lacks kaempferol–3–0–rhamnoside, kaempferol–3–0–galactoside and the 6″–0–gallyl derivative of the flavonol glucosides. Kaempferol–3–0–galactoside occurs only as a trace constituent of *J. parryi;* it was not sought in *J. malvifolia* due to lack of plant material.

Two types of gallic acid derivatives occur: the 6″–0–gallylated flavonol glucosides and an unidentified compound indicated only as positive "gallotannin test". The capacity to make gallic acid derivatives characterizes the genus; the nature of the derivatives appears to be useful in assessing relationships.

Despite the limited taxonomic value of the flavonoid differences within *Jepsonia* it is of interest that *J. parryi* and *J. malvifolia,* which have adjacent geographical ranges and show the largest degree of crossability (Ornduff, 1969), should exhibit identical pigment profiles.

Ornduff (1969) stated that, while *Jepsonia* has no close relatives in

the family, it may be allied with such genera as *Bolandra, Boykinia, Heuchera, Darmera (Peltiphyllum), Suksdorfia* and *Tellima.* Since detailed flavonoid data are available on all of these except *Bolandra,* some intergeneric comparisons are possible.

*Heuchera micrantha* Dougl. var. *diversifolia* (Ryd.) R. B. & L. and *H. cylindrica* Dougl. var. *glabella* (T. & G.) Wheelock possess exceedingly complex flavonoid mixtures; at least 60 compounds occur in the former and about 40 are known in the latter (Wilkins and Bohm, 1976a; and unpubl.). The major compounds are flavonols which exist in a wide variety of mono-, di-, and triglycosylated forms. The flavonols are kaempferol, quercetin, and myricetin but small quantities of the 0–methylated flavonols isorhamnetin, larycitrin, and syringetin also occur. Both *Heuchera* species possess 6″–0–gallyl derivatives of kaempferol and quercetin glucosides, accumulate a small amount of the flavone luteolin, and have a variety of tannins.

*Tellima grandiflora* (Pursh) Dougl. has a simpler array of compounds but shares with *Heuchera* the ability to make gallylated flavonol derivatives. It does not have flavone derivatives. *Tellima* is the only genus of Saxifragaceae so far studied that produces 4′–0–glucosides (Collins and Bohm, 1974). It also has a complex array of tannins (Wilkins and Bohm, 1976b, c).

*Damera peltata* (Torr.) Voss also has fewer compounds than *Heuchera* although they share some flavonol mono- and diglycosides. Tannins are also present in *Darmera* but they appear to be simpler than those in *Heuchera* or *Tellima* (Bohm and Wilkins, 1976).

Preliminary study of *Suksdorfia ranunculifolia* (Hook.) Engl. (Bohm, unpubl.) showed a very simple array of flavonol mono-, di-, and triglycosides. Gallylated flavonol glycosides were not observed in *Darmera* or the one *Suksdorfia* species examined.

Finally, studies of *Boykinia* (Gornall and Bohm, unpubl.) show the presence of flavonols and flavones in roughly equal amounts. A moderately simple pattern of monoglycosides is present but the complex array of diglycosides is reminiscent of *Heuchera.* Gallylated flavonol glycosides do not appear to be present, but 6–hydroxylation and 3–0–methylation occur, which characters have been seen in the family so far only in *Chrysosplenium* (Bohm et al, 1977, and ref. cited therein).

As in all of the genera of Saxifragaceae whose flavonoid profiles have been studied to date, *Jepsonia* has a unique combination of compounds. However, the flavonols present and their glycosylated derivatives are clearly related to those found in other members of the family. *Jepsonia* most closely resembles *Darmera* in its flavonol glycosides *per se.* The presence of gallylated flavonol glycosides and other simple gallic acid derivatives in *Jepsonia* suggests possible relationships with the two tannin-producing genera studied to date: *Heuchera* and *Tellima.*

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Literature Cited

Bacigalupi, R. 1944. *Jepsonia*. *In* Abrams, L. Illustrated Flora of the Pacific States 2:54. Stanford University Press, Stanford, California.

Bohm, B. A., F. W. Collins, and R. Bose. 1977. Chemotaxonomic studies in the Saxifragaceae s.l. 7. The flavonoids of *Chrysosplenium tetrandrum*. Phytochemistry 16: in press.

———, and C. K. Wilkins. 1976. Chemotaxonomic studies in the Saxifragaceae s.l. 6. Flavonoids and gallic acid derivatives of *Peltiphyllum peltatum*. Phytochemistry 15:2012–2013.

Collins, F. W. and B. A. Bohm. 1974. Chemotaxonomic studies in the Saxifragaceae s.l. 1. The flavonoids of *Tellima grandiflora*. Canad. J. Bot. 52:307–312.

———, B. A. Bohm, and C. K. Wilkins. 1975. Chemotaxonomic studies in the Saxifragaceae s.l. 2. Flavonol glycoside gallates from *Tellima grandiflora*. Phytochemistry 14:1099–1102.

Jepson, W. L. 1923–1925. A manual of the flowering plants of California. Associated Students Store, University of California. Saxifragaceae: pp. 454–475.

———. 1936. Saxifragaceae: *In* A flora of California 2:116–159. California Book Depository.

Mabry, T. J., K. R. Markham, and M. B. Thomas. 1970. The systematic identification of flavonoids. Springer-Verlag, New York.

Munz, P. A. 1959. A California flora. University of California Press, Berkeley and Los Angeles.

Ornduff, R. 1961. Heterostyly in *Jepsonia* (Saxifragaceae). Recent advances in Botany (IX International Bot. Congress, Montreal, 1959) 1:885–887.

———. 1969. Ecology, morphology, and systematics of *Jepsonia* (Saxifragaceae). Brittonia 21:286–298.

Small, J. K., and P. A. Rydberg. 1905. Saxifragaceae. North American Flora 22: 18–20.

Wilkins, C. K., and B. A. Bohm. 1976a. Chemotaxonomic studies in the Saxifragaceae s.l. 4. Flavonoids of *Heuchera micrantha* var. *diversifolia*. Canad. J. Bot. 54:2133–2140.

———. 1976b. Chemotaxonomic studies in the Saxifragaceae s.l. 3. Ellagitannins of *Tellima grandiflora* Phytochemistry 15:211–214.

———. 1976c. Chemotaxonomic studies in the Saxifragaceae s.l. 5. Complex ellagitannins of *Tellima grandiflora*. Planta Medica 30:72–74.